tion, the water in these fissures circulates freely. This line of saturation is governed in this as well as in all other permeable formations, by the level of the lowest natural point of escape, which is either the coast-line if near, or the nearest river-valley. Below these levels permeable strata are always charged with water; consequently under London the chalk is everywhere water-bearing; but as the Lower Chalk is more compact than the Upper, and is less fissured, especially when covered by other strata, and as the more compact water-logged chalk delivers its charge with extreme slowness, it is not until a fissure is met with that a free supply of water is obtained. Further, as there is no law regulating the position of the fissures, the depth to which the chalk has to be traversed before meeting with a free supply of water is quite uncertain. It is a question of probability depending upon meeting with a fissure sooner or later—10 to 15 feet have sufficed in some of the deep London wells, whereas in others it has been necessary to sink to a depth of from 100 to 200 feet or more before hitting on the necessary fissures. Large as this supply is, the same causes which have operated in the case of the sands have told also on the chalk supplies (and, no doubt, there is some community between tbe two), and the great demands on it have occasioned a similar lowering of the water-line. At the same time this line also remains unaltered at a distance from London, and as with Tertiary Sands the mass of the chalk beneath intersecting the level of the river valleys remains constantly charged with water. Ordinary wells, therefore, sunk below this line of saturation into the chalk where it comes to or near the surface, are capable of yielding very large quantities of water. More than seven million gallons daily are in fact now so obtained from the chalk on the south-east of London.

Numerous and useful as the London Artesian wells are, they sink into insignificance when compared with the application of the same system in Paris. Our deepest wells range from about 400 to 500 feet, and the water comes from the chalk hills at a nearest distance of from 15 to 25 miles from London; whereas in Paris the well of Grenelle is 1,798 feet deep, and derives its supplies from the rain-water falling in the Lower Greensands of Champagne, and travelling above 100 miles underground before reaching Paris. The well of Passy, sunk also through the Chalk into the Lower Greensands at a depth of 1,923 feet, derives its supplies from the same source. The level of the ground above the sea at the outcrop of the Lower Greensands in Champagne averages about 350 feet, and the water at Grenelle well rises 120 above the surface, which is nearly the level of the Seine, there 89 feet above the sea-level. The water-delivery is large and well maintained. These results were considered so encouraging, that in 1865 the Municipality of Paris decided on sinking two Artesian wells of unexampled magnitude. Hitherto the bore-holes of such wells have been measured by inches, varying from 14 to 4 inches, that of Passy alone having been 4 feet at the surface and 2 feet 4 inches at bottom. But it was resolved to exceed even the larger dimensions of this well.

One of these experimental wells is in the north of Paris, at La Chapelle, St. Denis, 157 feet above the sea-level. A shaft, with a diameter of of 6½ feet, was first sunk through Tertiary strata to a depth of 113 feet. At this point the boring was commenced with a diameter of 5½ feet, and carried through difficult Tertiary strata to a depth of 450 feet, when the Chalk was reached. A fresh bore-hole was here commenced in August 1867, which in September 1870 had reached the depth of 1,954 feet. The works were stopped on account of the war until June 1871, when they were resumed, and the bore-hole has now reached the great depth of 2,034 feet, with a diameter still of 4 feet 4½ inches. It is now in the Grey Chalk, and it is calculated that the Lower Greensands will be reached at a depth of about 2,300 feet.

The other Artesian well is at the Buttes-aux-Cailles, on the south-east of Paris, at an elevation of 203 ft. above the sea. The Tertiary strata are there only 205 ft. thick. This well is not quite on so large a scale as the other, and is still, at the depth of 1,640 ft., in the White Chalk.

The discharge from these great wells will probably be equal to that of a small river. At Passy, notwithstanding some defective tubage, and the circumstance that the surface of the ground is there 86 ft. above the Seine, the discharge at the surface is equal to 3½ millons of gallons daily; and it has been above 5 millions, or enough for the supply of a town of 150,000 inhabitants.

The question may arise, and has arisen, why, with a like geological structure, should not like results be obtained at London as at Paris; and, to a certain extent, it has been answered. At Kentish Town an Artesian well was, in 1855, carried through 324 feet of Tertiary strata, 645 ft. of Chalk, 14 ft. of Upper Greensand, and 130 ft. of Gault. Instead of then meeting with the water-bearing Lower Greensands which crop out from beneath the Chalk, both on the north and south of London, unexpected geological conditions were found to prevail, to which we shall have occasion to refer presently; and not only were these Greensands found to be absent, but likewise all the Oolitic and Liassic series. The bore-hole passed at once from the Gault into a series of red and grey sandstones, probably of Palæozoic age, and not water-bearing. The Chalk has more recently been traversed at Crossness, near Plumstead, where its base was reached at a depth of 785 ft., and the bore-hole carried 159 ft. deeper into, but not through, the Gault, when, owing to difficulties caused by the small size of the bore-hole, the work had to be abandoned. Although we were mistaken in our anticipations as to the results of the first of these works, still it is evident—as the Lower Greensands, with a thickness of 450 ft., pass beneath the Chalk and the Gault in a line from Farnham, Reigate, to and beyond Sevenoaks—and they again occupy the same position north of London, on a line from Leighton Buzzard to Potton—that it is only a question of how far they may be prolonged underground towards London. They have as yet been followed only 4 miles from their outcrop under the Gault in Buckinghamshire, and 1 mile in Kent; and no attempt has been made to follow them under the Chalk. It is therefore quite possible that they may extend to under Croydon, or even to Sydenham, or still nearer London; but this depends upon the width of the underground ridge of Palæozoic rocks, which has not been determined. It is a matter for trial. As the sands are from 200 to 500 ft. thick, and show no sign of an immediate approach to the old shore-line, there is every probability that in Kent and Surrey they extend at all events some miles northward, and in Bucks some miles southward, before they thin off against the underground ridge of old rocks, so that they might still be found available, as a supplementary source, for the water-supply of London.

Such is the geological structure of the ground on which this large city is dependent for its first and immediate water-supply by means of wells. The highest seam of water, that in the drift-gravel, extends almost everywhere under the streets and houses of London, at depths of from 12 ft. to 25 ft., forming what is called ground-springs. The Lower Tertiary sands, with their greater thickness, and their larger and distant area of outcrop, contain the second and larger underground body of water beneath London. The third underground reservoir is the Chalk, which, from its large dimensions—500 ft. to 1,000 ft. thick—and extensive superficial area, forms a still larger reservoir, and source of water-supply.

With the increase of population, however, the need for larger quantities necessitated the recourse to river-supply; and this supply, equally with the other, is regulated by geological conditions, only that in this case the question concerns those conditions which affect the strata throughout the catchment-basin of the river itself above the town which needs its supply.

(*To be continued.*)

PROF. SCHIAPARELLI'S RESEARCHES

THE following address was delivered by the president of the Royal Astronomical Society, Mr. William Lassell, February 9, 1872, on presenting the Gold Medal of the Society to Signor Schiaparelli:—

You will have learned from the Report just read, that your Council have awarded the Gold Medal this year to Signor Schiaparelli; and I regret to have to inform you that we shall be deprived of the pleasure of presenting it to him in person; as by a letter received from him a few days ago, I learn that his duties of Professor and Director of the Observatory at Milan will prevent his being able to undertake so long a journey.

The first notice I find of Signor Schiaparelli's labours is his discovery of the minor planet *Hesperia*, at the Observatory of Milan, on April 29, 1861, an indication that, besides his mathematical attainments in Theoretical Astronomy, he possesses industry and practical skill as an observer.

In the *Astronomische Nachrichten* of August 13, 1864 (No. 1487), is a purely mathematical paper by him, entitled "Théorèmes sur le mouvement de plusiers corps qui s'attirent mutuellement dans l'espace." Of this paper, not bearing immediately upon those labours of Signor Schiaparelli which have more especially called forth the award, I will only express the opinion of a friend of high mathematical attainments, who characterises it "as an elegant and probably original contribution to the theory of the orbits of bodies moving freely in space, and acted on only by their mutual attractions."

I come now to give some account of Signor Schiaparelli's principal discovery of the law of identity of meteors and comets, and of the observations and reflections which led him to that result, as contained in a series of letters to Father Secchi in the year 1866.

It appears from these that Signor Schiaparelli's study of this subject received a great impulse from his own observation of the meteors which fell on the nights of the 9th, 10th and 11th of August, 1866. He states that he was then confirmed in the opinion expressed three years before, that, of the meteors which usually fall on those nights, a great number are distinguished by their starting nearly all from one point. And, from the spasmodic fall of these meteors—more sometimes falling in one minute than in the next quarter of an hour—he inferred that their distribution in space must be very unequal. He also observed that those stars proceeding from one point were all of a fine yellow colour, and left behind them a fugitive but very sensible track; whilst the other meteors, proceeding from various points, offered every variety of colour and form. Hence he concludes that the meteors form a number of rings, and become visible when the earth traverses their orbit, as if shooting forth from one point in the sky. And he remarks that the observations of M. Coulvier-Gravier, and Professor Heis, and of our own countrymen, Professor Herschel and Mr. Greg, have shown that these radial points occur in every quarter of the heavens; therefore these rings or orbits must possess every possible degree of inclination to the ecliptic.

He then proceeds to inquire how such a mass of cosmical matter could become accumulated in the Solar System. This system seems to consist of two classes—the planets, characterised by but little eccentricity of orbit, slight variation of the plane of the orbit, exclusion of retrograde motion, and a tendency to take the form of a sphere (deviating from it only so much as is necessary to preserve the equilibrium of the body)—these characteristics applying also to the secondary systems, with the exception of the satellites of *Uranus*. The second class consists of cometary bodies, which are under no law as to the planes of their orbits, or the direction of their motions. The point most remarkable about them is the extreme elongation of their orbits, most of which are described in stellar space; which seems to show that they did not form part of our system when that was first constituted, but are wandering nebulæ picked up by our sun.

Signor Schiaparelli further observes that the velocity of the solar system through space has been shown by Otto Struve and Airy to be somewhat similar to that of the planets round the sun. Now if a nebulous body or comet in motion were to come within the action of the sun, it would go round the sun at such an immense distance from us, that it would remain invisible. Two circumstances might bring it within our range of vision—first, if the comet met the sun in almost a direct line; and secondly, if it were travelling in a direction parallel to the sun's motion.

If we suppose a cloud of cosmical matter formed of particles so minute and so widely separated as to possess scarcely any mutual attraction, to be brought within the power of the sun's influence, each particle would pursue an elliptic orbit of its own. Those particles which differed most in the *planes* of their orbits would however possess *nodes in common*, and, in consequence, the particles as they approached the sun would necessarily approach each other, and when separating again, after passing the node, would at their perihelion passage be still very much nearer than they were when brought first within the sun's attraction. Those particles which, lying in the same plane, presented a wide angle with respect to the sun, would form *ellipses*, the planes of which would be identical; though the positions of the major axes would diverge, and, as a result, the particles at their perihelion would pass in nearly the same orbit, but at different velocities, the originally foremost particle being overtaken by those behind it. Again, those particles which, being in the same *plane*, were also in the same *line with regard to the sun*—their separation consisting in the variation of their distance from the sun—would form *ellipses in the same plane*, and having a major axis in the same direction, but of different lengths,—the orbit of the particle *nearest* the sun being described *within* that of the farthest particle, the result of which would be a difference of speed, and an ever-widening distribution of the particles along the whole of the orbit. This reasoning is illustrated, in the second letter to Father Secchi, by a series of diagrams and figures; and then Signor Schiaparelli proceeds to give a recapitulation or summary of his principal propositions thus:—Celestial matter may be divided into the following classes, 1st, fixed stars; 2nd, agglomerations of small stars (resolvable nebulæ); 3rd, smaller bodies invisible except when approaching the sun (comets); 4th, small particles composing a cosmical cloud. This last class probably occupies a large portion of the celestial spaces, and the motion of these dust-clouds may be similar to that of the fixed stars. When attracted by the sun they are not visible unless they receive an orbit which is an elongated conic section.

Whatever may have been the original form of the cloud, it cannot penetrate far into our system without assuming the form of an elongated cylinder passing gradually into a stream of particles. The number of such streams seems to be very great. The particles are so scattered that their orbits may cross each other without interruption, and may possibly be always changing like the beds of rivers. The stream, after passing its perihelion, will be more diffuse than before; and, when passing a planet, may be so violently affected as to separate or break up, and even some particles may assume quite a new orbit and become independent meteors.

Thus meteors and other celestial phenomena of like nature, which a century ago were regarded as atmospheric phenomena—which La Place and Olbers ventured to think came from the moon, and which were afterwards raised to the dignity of being members of the planetary system—are now proved to belong to the *stellar regions*, and to be, *in truth*, *falling stars*. They have the same relation to comets as the asteroids have to the planets; in both cases their small size is made up by their greater number.

Lastly, we may presume that it is certain that falling stars, meteors, and aerolites, differ in size only and not in composition; therefore we may presume that they are an example of what the universe is composed of. As in them we find no elements foreign to those of the earth, we may infer the similarity of composition of all the universe—a fact already suggested by the revelations of the spectroscope.

Signor Schiaparelli further pursues the subject in another and later paper, published in No. 1629 of the *Astronomische Nachrichten*, entitled "Sur la Relation qui existe entre les comètes et les étoiles filantes." In this communication he refers to the letters to Father Secchi above referred to, in which he had endeavoured to bring together all the arguments in favour of the opinion of an analogy between the mysterious bodies known as shooting stars and comets.

Signor Schiaparelli, in this paper, proceeds to state that he is prepared to afford to this analogy a large amount of probability, since there is no doubt that certain comets, if not all, furnish the numerous meteors which traverse the celestial spaces. In proof of this Signor Schiaparelli quotes from a paper of Prof. Erman, in which he has pointed out the method of obtaining a complete knowledge of the orbit described by a system of shooting stars, when the apparent position of the point of radiation and the velocity through space of the meteors is known.

Assuming from the necessity of the case that the orbit of the August meteors must be an elongated conic section, Signor Schiaparelli employs the method of Erman to calculate the parabolic orbit of those bodies; taking right ascension 44° and north declination 56° for the position of the point of divergence, according to the observations made in 1863 by Prof. A. S. Herschel. And he proceeds to give the following elements, assuming the maximum of the display of 1866 to be August 10, 18 hours. Comparing these elements of the orbit of the August meteors with those of the orbit of Comet II. 1862, calculated by Dr. Oppolzer, he exhibits the following remarkable coincidence in each element:—

	Elements of the Orbit of the Aug. Meteors.	Elements of the Orbit of Comet II, 1862
Perihelion Passage	23 July, 1862	22·9 Aug., 1862
	° ′	° ′
Longitude of Perihelion	343 28	344 41
Ascending Node	138 16	137 27
Inclination	64 3	66 25
Perihelion Distance	0·9643	0·9626
Revolution Period	105? years	153·4 years
Motion	Retrograde	Retrograde

Although the time of revolution of the August meteors is still doubtful, Signor Schiaparelli, on reference to the catalogues of Biot and Quetelet, deduces a hypothetic period of 105 years, which introduces but small changes in the elements—very inferior to the uncertainty of some of the data on which this determination is built.

In the letters above referred to, Signor Schiaparelli had given an orbit for the meteors of November, assuming the point of radiation as determined in America to be γ *Leonis*. But later observations made with much care in England have shown that this position is erroneous by several degrees, so that that orbit can only be termed a very rough approximation. Assuming, then, that the point of radiation is longitude 143° 12′ and latitude 10° 16′ north—that the maximum of the shower was November 13, 11h. G.M.T.—and that the period of revolution is $33\frac{1}{4}$ years, according to Prof. Newton—Signor Schiaparelli compared the following elements of the meteoric orbit, which he compared with those of the orbit of Comet I., 1866, calculated by Dr. Oppolzer.

	Elements of the Orbit of Nov. Meteors.	Element of the Orbit of Comet I, 1866.
Perihelion Passage	Nov. 10·092, 1866.	Jan. 11·160, 1866.
	° ′	° ′
Longitude of Perihelion	56 25·9	60 28
Ascending Node	231 28·2	231 26·1
Inclination	17 44·5	17 18·1
Perihelion Distance	0·9873	0·9765
Eccentricity	0·9046	0·9054
Semi-axis Major	10·340	10·324
Revolution Period	33·250 years	33·176 years
Motion	Retrograde	Retrograde.

The assumed position of the point of radiation of the meteors is the mean of 15 determinations obtained by Prof. A. S. Herschel, and given in the *Monthly Notices* of our Society, vol. xxvii. p. 19. If this point be advanced 2° in longitude, and 145° be taken in lieu of 143°, the difference of 4° in the place of the longitude of perihelion in the above elements will disappear.

Signor Schiaparelli then concludes his memoir in these remarkable words :—"These approximations need no comment—must we regard these falling stars as swarms of small comets, or rather as the product of the dissolution of so many great comets? I dare make no reply to such a question."

In venturing to offer a word or two of comment on this very imperfect *résumé* of the labours of Signor Schiaparelli, it appears to me that we can scarcely speak of them too highly, or overrate their importance. Granting that his hypotheses are correct,—of which indeed there seems to be a very high probability, some of the most difficult questions in the contemplation of the constitution of the universe seem at once, and as it were *per saltum*, to be solved. To have placed before our view so clear a history of those mysterious bodies—nebulæ, comets, and aerolites, and their several and intimate relations pointed out—is an advancement of Astronomical Science I at least individually had not ventured to anticipate. And a collateral advantage resulting from this splendid discovery, is the encouragement given to the careful and diligent observation of phenomena, even when the prospect of a fruitful result is by no means apparent. Had it not been for the patient, systematic, and intelligent observations of Prof. Heis, M. Coulvier-Gravier, Mr. Greg, and Prof. Herschel, Signor Schiaparelli would have wanted many valuable data required in his investigations.

I may finally remark that an important confirmation of Signor Schiaparelli's conclusions appears in a valuable paper of Prof. Adams, in our *Monthly Notices*, vol. xxvii. p. 247, in which from somewhat different data, including some observations of his own, he calculates elliptic elements of the November meteors generally very accordant with those above given.

SOCIETIES AND ACADEMIES

LONDON

Geological Society, March 6.—Prof. Duncan, F.R.S., vice-president, in the chair.—(1.) "*Prognathodus Güntheri* (Egerton), a new genus of fossil Fish from the Lias of Lyme Regis." By Sir P. de M. Grey-Egerton, Bart, M.P., F.R.S. In this paper the author described a new form of fossil fish, having a broad premaxillary plate somewhat resembling the incisor tooth of a gigantic Rodent, a single auxiliary plate like that of *Callorhynchus*, and a mandibular dental apparatus closely resembling that of *Cochliodus*. For this form he proposed the establishment of the new genus *Prognathodus*, and named the species *P. Güntheri*. *Ischyodus Johnsoni*, Agassiz, also probably belongs to this genus, as it agrees with *P. Güntheri* in the characters of the premaxillary teeth. The author was doubtful as to the exact position of this genus, which had a head extended in a horizontal instead of a vertical plane, suggesting a resemblance to *Zygæna*, but covered with hard plates like the head of a sturgeon, and exhibited in the dental apparatus the curious combination indicated above.—Dr. Günther pointed out the interest attaching to the dentition of this fossil fish as proving the connection between the Ganoid and Chimæroid forms. The existence of three teeth instead of one on each side of the jaw, as in *Ceratodus* and others, presented in it a generic character; but the type was still the same. Mr. Etheridge made some observations as to the horizon in the Lias in which these fossil fishes occurred. He believed that nine out of ten of the Lower Lias Species came out of the upper part of the *Bucklandi* limestone series. Sir P. Egerton corroborated Mr. Etheridge's views as to the localisation of species of fish, and agreed with him as to the importance of recording the exact position of all such fossils.—(2.) "On two specimens of *Ischyodus*, from the Lias of Lyme Regis." By Sir P. de M. Grey-Egerton, Bart., M.P., F.R.S. In this paper the author noticed a new example of the greatly developed rostrum of a male Chimeroid, an inch shorter, more slender, and more attenuated at the apex, than that of *Ischyodus orthorhinus* Egerton, having a projecting median rib along the upper surface, and the tubercles of the lower part smaller and fewer than in *I. orthorhinus*. For this form the author proposed the name of *I. leptorhinus*. Also a dorsal fin-spine, with the cartilages to which it was articulated, showing the mechanism of its attachment very clearly. This spine differs from that of *I. orthorhinus* in being straighter and smoother, and having fewer and smaller tubercles. The author regarded it as probably belonging to *I. leptorhinus*—(3.) "How the Parallel Roads of Glen Roy were formed." By Prof. James Nicol, F.G.S. In this paper the author endeavoured to explain, in accordance with the marine theory of the origin of the Parallel Roads of Glen Roy, the coincidence of the level of these terraces with that of the different cols, and also how the same sea could have produced terraces at different levels in different valleys. He assumed that during the gradual elevation of the land, the gradual closing of the straits between its separate masses by the elevation of the cols above the surface would, by checking the eastward flow of the tidal current, cause the sea-level in the western bays to remain stationary relatively to the rising land; and during this period the marine erosion would take place along a line corresponding in level to the col. Hence, in Glen Gloy, which has only one col, the highest in the system, the highest road only was formed; and Glen Gloy remained unaffected by the stoppage of those cols which produced three roads at lower levels in Glen Roy, the lowest of them also extending round Glen Spean. Professor Ramsay entered into the history of the theories for accounting for the terraces, the first of which, that of Professor Agassiz (in 1840), accounted for them by a great glacier damming up the valley, and from time to time declining in height. The glacial theory, on which this view rested, had to some extent been doubted, but eventually had been almost universally accepted even by its first opponents. He next cited the works of the late Mr. Robert Chambers as to the existence of old sea-margins, pointing to a gradual sinking of the sea or a rising of the land. There could be little doubt that a great part of Scotland and of the northern part of England, had been at one time covered with glaciers, as had also been the case in other parts of Europe. Unless the whole country had been submerged, and then came up again by a succession of jerks, it seemed impossible that such terraces could have been formed by the sea and still have remained in existence. If, however, there had been great oscillations in temperature, it seemed possible that during the decline of some transverse glacier the varying levels of the lake might have left terraces, traces of which might still be preserved. Mr. Gwyn Jeffreys renewed his protest against regarding these beds as marine unless marine remains were found in them. In Prof. Nicol's former paper, mention, however, had been made of rolled boulders. These occurred at Glasgow, and elsewhere, covered with *Balani*. As, however, no marine remains had been found in Glen Roy, he adopted the freshwater theory. Mr. Evans regretted that no one else was present who would in any degree advocate the author's views. He pointed out that if the surface of the rocks below the detritus in Glen Roy was glaciated, the probability was in favour of the superficial drift being of marine rather than of subaërial origin. He much doubted